CONFIDENTIAL

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TWENTY-FIFTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

105 MM BATTALION ANTI-TANK PROJECT

Contract No.
DA-33-019-ORD-33 (Negotiated)
RAD ORDTS 1-12383

THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio

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CONFIDENTIAL

INDEX

ABSTRACT

Two conferences concerning BAT weapon and ammunition were held in Office, Chief of Ordnance during the past month. Certain decisions involving changes in requirements for weapon and ammunition were made. These changes are described. To comply with the revised requirements, the T137E3 rifle has been redesigned so that, with the proper tube and vent ring, any one of three "packages" of ammunition can be fired from it.

The M32 shell case, through simple modifications, is being used in all rounds of Firestone BAT ammunition. The necessary changes for the various type projectiles are itemized.

An inventory of the Firestone BAT weapon systems is presented. Two tables list all the revision numbers for the various rifles and mounts and give the salient features of each.

A group of 78 rounds of spotter-tracer ammunition, fired for test purposes, had an excessive velocity spread and were returned to Winchester Repeating Arms for reloading.

The number and type of T138E57 rounds being prepared for tests at Aberdeen Proving Ground and for Field Forces Board tests are summarized.

The various E modifications of the T119 projectile are illustrated and the features of each listed in Tables III to XII. Data are presented for three experimental programs on the T119 projectile: (1) a charge development program for the projectile fired from 95 in. and 105 in. tubes; (2) structural tests on piston, chamber and housing; (3) accuracy firings with the E8 modification from the T137 rifle at 1000 yards.

The derivation of a velocity and a bias angle for the T189 spotter-tracer to match the T119 projectile is presented.

The following penetration studies are reported: (1) penetration results of machined versus drawn copper liners; (2) the effect of internal tee configuration on penetration; (3) penetration results with DRB 398 cones modified for and fired in 90mm assemblies.

Tests were continued to investigate the functioning characteristics of barium titanate crystal. The DRD 328 base element for the T222 E5 fuze was tested for functioning in firings at E.O.D. The fuze, T222E2, PD, was given the Jolt and Jumble test and was fired for recovery to check the arming efficiency.

THE WEAPON SYSTEM

Two meetings held in Office, Chief of Ordnance (ORDTS and ORDTA) on August 8 and 16 concerning the BAT project resulted in certain decisions regarding the weapons and ammunition types.

RIFLE

It was requested that the BAT rifle, T137, be examined with a view toward making such modifications as necessary, so that it might, with as few changes as possible, fire all types of BAT ammunition i.e., the ammunition developed for the T170 and M27 rifles as well as that for the T137.

AMMUNITION

A decision was made that no package of ammunition (HEAT, HE and WP) should contain more than one finned round. Because of the effect of spin upon penetration the finned round is to be a HEAT round. This ammunition requirement makes the following combination packages of projectiles permissible.

(1) T138E57 HEAT, T263 HE, T264 WP— fired from 1-200 tube.

(2) T119 HEAT, M323 HE, M325 WP, M326 (or T139E36) HEP—fired from 1-20 tube.

(3) T184 HEAT, M323 HE, M325 WP, M326 (or T139E36) HEP—fired from 1-20 tube.

Rifle Changes

In order to comply with the revised requirements, the T137E3 rifle was designed so that, with the proper tube, any unit of the above permissible ammunition could be fired. To make this possible it was necessary to provide a counterbore in the tube and to revise the interior contour of the chamber.

Beyond these required changes the following modifications have been made:

(1) The tube length was increased to 105 in.

(2) The breech mechanism was made the same as the M27 breech mechanism.

(3) The chamber was made stronger to allow for a full 20% reduction in the yield strength of the material at high temperatures.

Table I summarizes the various T137 rifle modifications.

Cartridge Case Changes

The M32 cartridge case, now in production, and therefore readily obtained, is easily modified for use in the T137E3 rifle. Because the pressures in this rifle are higher than in the M27 rifle it has been found necessary to heat treat the M32 shell cases. Some preliminary experiments indicate that it may be possible to alter the ignition so as to make heat treating of the shell cases unnecessary. Further tests are planned. The new designations for the modified M32 cases are as follows:

T52E1—Expanded mouth, heat treated and enlarged primer counterbore for use with

T138E57 HEAT rounds
T263 HE rounds
T264 WP rounds
For firing from T137E3 rifle

T52E2—Standard mouth, heat treated, enlarged primer counterbore, for use with

M323 HE round
M325 WP round
M326 (or T139E36) HEP round
For firing from T137E3 rifle

T53E1—Expanded mouth, heat treated, enlarged primer counterbore and plug

in base for rear loading, for use with
T119 HEAT round
For firing from T137E3 rifle

Mount Changes

As a result of tests at Erie Ordnance Depot and Aberdeen Proving Ground and preliminary tests at Fort Benning, Georgia various modifications have been made of the original T152 mount. The modifications and the features of each are shown in Table II.

Weapon System Distribution

As reported in the Twenty-Third and Twenty-Fourth Progress Reports four BAT weapon systems were in use at various locations. Below is a revised inventory of these systems.

Components of Units:—T137E1 rifle, T152E2 mount, T46 spotting rifle, M62E4 direct sight, T183 direct sight mount, M38 truck.

One Unit - Fort Benning, Georgia, for informal evaluation tests of weapon and ammunition.
Change - Spotting rifle returned to Springfield Armory.

Two Units - Erie Ordnance Depot for Firestone weapon and ammunition studies.
Change - Spotting rifle returned to Springfield Armory.

One Unit - Aberdeen Proving Ground for ammunition evaluation.
Change - Spotting rifle returned to Springfield Armory and M38 truck taken for use with another system (T137E2 rifle and T152E4 mount; See Tables I and II).

Four additional weapon systems are being constructed. The components and status of each are given below:

Components of Units:—T137E2 rifle, T152E4 mount, T46 spotting rifle, M62E4 direct sight, T183 direct sight mount and M3A1E1 indirect sight.

One Unit - Completed and proof tested at Erie Ordnance Depot and shipped to Aberdeen Proving Ground for use in accuracy tests of the T138 and T119 projectiles.

One Unit - Completed and proof tested at Erie Ordnance Depot. This unit is without spotting rifle and sights.

Components of Units:—T137E3 rifle, T152E4 mount, T46 spotting rifle, M62E4 direct sight, T183 direct sight mount and M3A1E1 indirect sight.

One Unit - T137E3 rifle replaces T137E2 rifle (See Table I). This unit to be completed by the first week in September and will be shipped to Aberdeen Proving Ground by September 9, for use in engineering tests. This rifle will replace the T137E2, mounted on the T152E4 mount.

One Unit - Also with T137E3 rifle, will be completed during the week of September 13. This system will use spotting rifle T46 No. 15.

Table I gives the features of the various T137 Rifles.

Spotting Rifle and Ammunition

A shipment of 300 rounds of Winchester spotter-tracer ammunition was received at Erie Ordnance Depot for evaluation tests, planned in cooperation with Winchester representatives. A group of 78 rounds was tested and since the velocity spread was excessive, the remaining rounds were returned to Winchester for reloading. The test data for the 78 rounds have been given to Winchester for analysis and reporting.

The spotter-tracer rounds were test fired from a T46 No. 13 rifle. During the firing the following difficulties were encountered:

(1) The barrel plug was loose in the receiver permitting the barrel to move in the receiver. (Approximately 175 rounds had been fired from this rifle when the difficulty was discovered).

(2) A recoil spring and spring guide were found about 20 feet behind the rifle. The guide had apparently disengaged from the locking lug in the back plate sometime during the recoil cycle. This same difficulty has been encountered with other T46 rifles during recent firings. The condition has been reported to Springfield Armory.

Future Program

1. Continue design study of an aluminum mount.

2. Continue design layouts of semiautomatic rifles.

3. Establish an experimental pressure-travel curve.

4. Investigate modified ignition systems to determine if non heat-treated cases can be used.

Table I
T137 Rifle Modifications

Rifle	Feature
T137	First model; failed during proofing.
T137E1	85-in. tube, Firestone breech mechanism.
T137E2	95-in. tube, modified M27 breech mechanism.
T137E3	105-in. tube, M27 breech mechanism, chamber contoured to fire the T170 rifle ammunition, as well as the T138 and T119 projectiles, full temperature compensation.

Table II

T152 Mount Modifications

Mount	Feature
T152	Single suspension, trunnions below center line of rifle.
T152E1	T152 mount redesigned for greater rigidity.
T152E2	Elevating mechanism attached forward of trunnions, trunnions mounted on center line of bore, taper leg locks, center fire control buttons, special thrust bearings.
T152E3	Similar to T152E2, improved by use of roller bearings and guide rails on elevating system.
T152E4	Similar to T152E3, ratchet-type leg locks, safety lock on firing mechanism, lock out for free traverse, free traversing lever, squeeze-type triggers located on handwheel knobs.
T152E5	To be completed approximately September 15. Identical to T152E4 mount except for a new tripod designed to attach to the top body flange of either the M38 or M38A1 truck.

T138 PROJECTILE

The program this month has been limited to the acquisition of rounds for use in engineering tests at Aberdeen Proving Ground and by Field Forces Boards. The following commitments for rounds, as set up at a conference at Office, Chief of Ordnance on August 20, 1952, are being met.

T138E57 (17.5 lb. HEAT)

Two hundred inert rounds for Aberdeen Proving Ground and AFF Board No. 3.

Two hundred thirty-five live loaded rounds for Aberdeen Proving Ground and AFF Board No. 3.

T263 (17.5 lb. HE)

Two hundred thirty-five live rounds for Aberdeen Proving Ground and AFF Board No. 3.

T264 (17.5 lb. WP)

Two hundred thirty-five WP loaded shells are to be shipped to Aberdeen Proving Ground and AFF Board No. 3.

T119 PROJECTILE

T119 Modifications

In the development of the T119 projectile, modifications were made from time to time but E numbers were not assigned. Tables III to XII illustrate each modification and list the component parts of each.

Charge Development

The T119 projectile has been fired from both 95-inch and 105-inch smooth bore tubes to ascertain the powder charge required to give the desired muzzle velocity. In the development of any powder charge it is necessary to obtain the desired muzzle velocity without exceeding the rated maximum pressure. In the case of the T119 it is also desirable that the powder completely fill the shell case since voids in the charge have resulted in damage to the fins during firing.

With these considerations in mind variable charges of two lots of M10 powder were used with two T119 modifications.

Firing From 95-Inch Tube

Two T119E4 projectiles and two T119E8 projectiles were fired from a T137E1 rifle with a 95-inch smooth bore tube using charges of Lot PA6084 (.038 in. web) and Lot PA30239 (.0335 in. web). Lot PA6084 failed to provide the required velocity with the cartridge case completely filled. The rounds fired with Lot PA30239 gave satisfactory values of pressure and velocity but the amount of powder used left an undesirable amount of void. The data are given in Table XIII.

Firing From 105-Inch Tube

Since it is known that a given powder charge will result in increased velocity as the tube is lengthened and since the recent revised design had called for a 105-inch tube, the powder lot PA6084 was investigated, using a 105-inch tube in a T137E2 rifle.

Two rounds of T119E8 modification were fired from the 105-in. tube using 8 lb. 5 oz. of PA6084 propellent. Satisfactory pressure and velocity figures were obtained (1707 ft/sec and 1685 ft/sec) and the charge filled the case. Since this test was conducted with a weapon having new or non-eroded vents and there is a tendency for the muzzle velocity to decline as the vents erode, the charge was tentatively set at 8 lb. 6 oz. of PA6084 powder. A charge verification was not fired at this time since the powder supply was exhausted. The charge development data are given in Table XIII.

Test of Housing and Piston Modifications

With production problems in mind, it was desirable to establish whether the tolerances could be relaxed on the piston and cylinder bore (See Fig. 1) without causing any malfunctioning of the fin opening mechanism.

The tolerance of the piston diameter (See Fig. 1) was changed from -.0005 in. to -.0015 and that of the cylinder bore of the housing from +.0005 to +.0010 in. These parts were machined to these new toler-

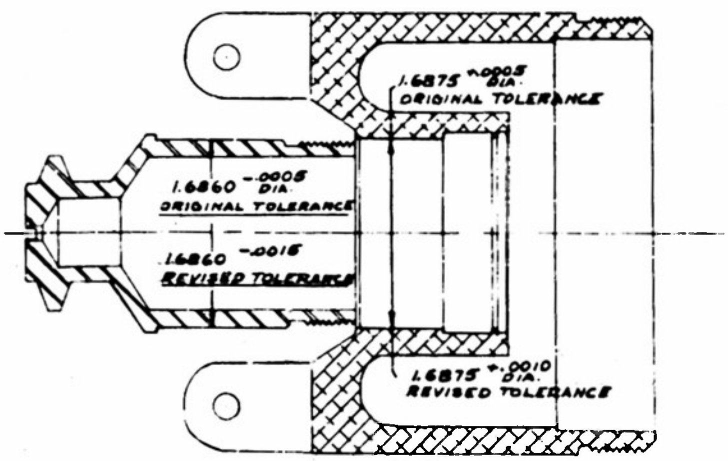


Fig. 1. Piston and Cylinder.

ances and a round containing these component parts was fired through yaw cards into a recovery box. An examination of the yaw cards and of the recovered projectile indicated that the fin-opening mechanism functioned in a satisfactory manner. The firing data are given in Table XIV.

Test of Chamber Modifications

There has been some question regarding the strength of the T119 projectile chamber. It was thought possible that the crimping operation (in crimping the T6 cartridge case to the projectile) might subject the housing to excessive strain. Chamber DRC442, shown in Fig. 2, was made heavier than preceeding models and by such construction the internal volume of the chamber was correspondingly reduced. It was then necessary to determine the effect of this change on the functioning of the fin-opening mechanism. One round using this housing was fired through yaw cards into a recovery box. Yaw cards indicated satisfactory function of the fin-opening mechanism and satisfactory flight. The firing data are given in Table XIV. Tests to investigate the crimping operation

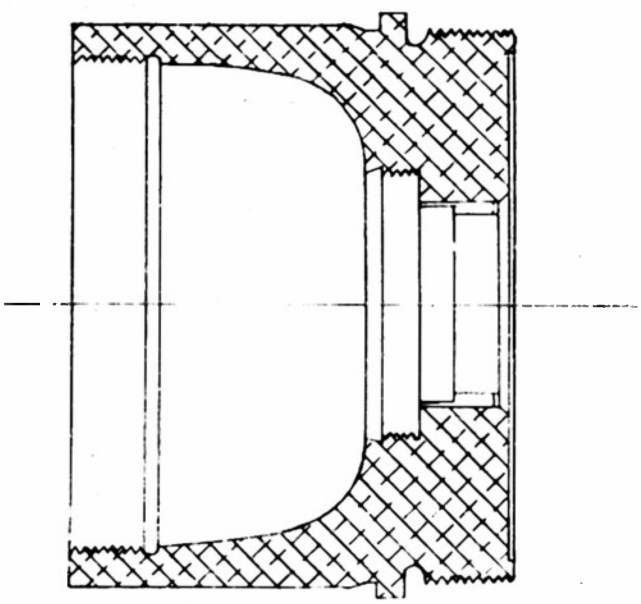


Fig. 2. Projectile Chamber.
Firestone Drawing No. DRC442.

and the effect on the projectile housing are planned at Picatinny Arsenal.

Forged Fins

Forged fins for T119 projectiles were used in two tests this month. Round 198 in Table XIII and round 199 in Table XV were assembled with forged fins (Drawing No. DRD334) and performed satisfactorily.

As a preliminary investigation of the forged fin the modified impact tester (see page 9, Twenty-First Progress Report) was used to determine the impact strength. Two fins sheared at impact energies of 91 and 82 ft-lb respectively and one fin fractured at 50 ft-lb. These results compare favorably with those obtained in testing machined fins (see Table I, page 10, Twenty-First Progress Report).

Accuracy Program

Twelve T119E8 (see Table X) rounds were fired for accuracy from a T137E2 rifle equipped with a 105-inch smooth bore tube. The purpose of the firing was to determine the accuracy of the E8 modification as compared to other earlier modifications. The E6 modification was used for the first time in the July 23 demonstration at Aberdeen Proving Ground and it was desired to determine if the rather poor performance observed at that time was representative of this modification.

All (12) projectiles fired in this accuracy program hit the target even though number 181 struck and cut three velocity coils near the gun. The coils were not reset when the aiming point was changed. Round 181 was omitted from the calculation of probable errors. The V.P.E. was .38 mil and the H.P.E. was .59 mil. No corrections were made for wind or muzzle velocity variations because poor observation conditions from the firing line caused some doubt about the sequence of impact points for a few of the rounds. The firing data are given in Table XV.

Production of the T119E8 projectile will be limited to a pilot lot of 550 rounds. This design is to be superceded by the T119E10 modification.

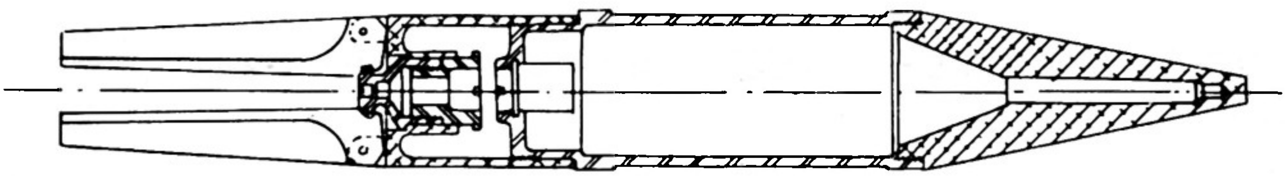
Future Program

1. Accuracy programs at 1500 and 2000 yards are planned for the week of September 8, 1952 at Aberdeen Proving Ground. For these programs T119E8 inert projectiles will be fired from the T137 rifle with a smooth bore tube.

2. A combined accuracy and penetration program at 1000 yards is planned for the week of September 8, 1952 at Aberdeen Proving Ground. For this program T119E8 projectiles will be fired from the T137 rifle with a smooth bore tube.

3. Tests are planned at Picatinny Arsenal to investigate crimping the T6 case to the aluminum chamber DRC442 of the T119E9 projectile.

Table III
T119E1 Modification

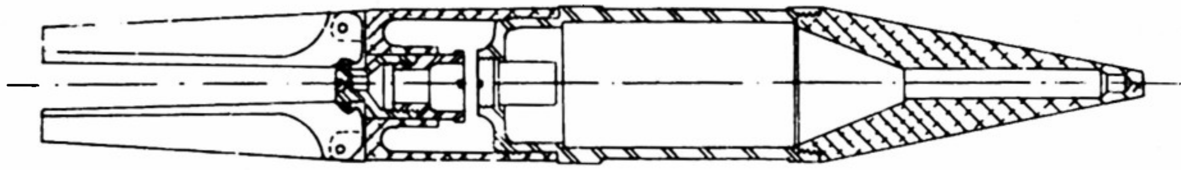


Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRB-50	24ST4	4.24
BODY	DRC-20	24ST4	7.34
HOUSING	DRC-19	24ST4	2.36
PISTON	DRB-55	SAE4140	.51
STOP	DRB-56	SAE4140	.38
FINS	DRB-49	24ST4	.98
BASE ELEMENT	DRA-10	24ST4	.28
PINS	----	STEEL	.08
ASSEMBLY	DRD 37-1		
INERT LOAD		PLASTER	5.33
PROJECTILE WEIGHT (CALCULATED)			21.50

C. P. .93 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G. 2.25 " " " " " " " "

TOTAL LENGTH - FINS CLOSED 32.12 IN.

Table IV
T119E2 Modification

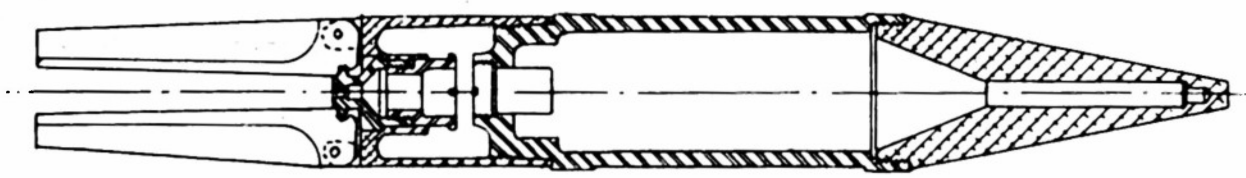


Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRB-50	24ST4	4.24
BODY	DRC-40	SAE4130	5.54
HOUSING	DRC-19	24ST4	2.36
PISTON	DRB-55	SAE4140	.51
STOP	DRB-56	SAE4140	.38
FINS	DRB-49	24ST4	.98
BASE ELEMENT	DRA-10	24ST4	.28
PINS		STEEL	.08
INERT LOAD		PLASTER	3.13
PROJECTILE WEIGHT (CALCULATED)			17.5

C. P. .73 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G 1.88 " " " " " " " "

TOTAL LENGTH - FINS CLOSED 29.00 IN.

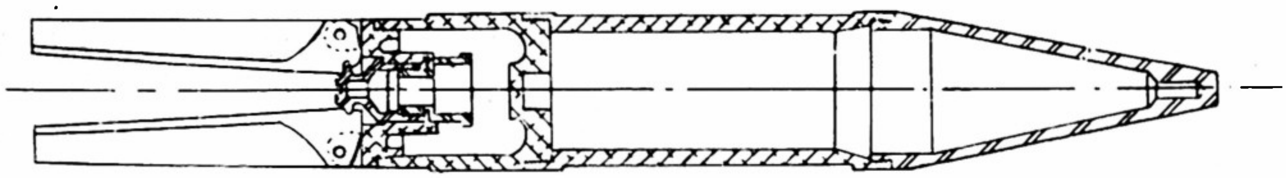
Table V
T119E3 Modification



Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRB-50	24ST4	4.24
BODY	DRC-23	24ST4	4.87
HOUSING	DRC-19	24ST4	2.36
PISTON	DRB-55	SAE4140	.51
STOP	DRB-56	SAE4140	.38
FINS	DRB-49	24ST4	.98
BASE ELEMENT	DRA-10	24ST4	.28
PINS	----	STEEL	.08
INERT LOAD		PLASTER	3.80
PROJECTILE WEIGHT (CALCULATED)			17.5

C. P. .93 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G. 2.26 " " " " " " " "
TOTAL LENGTH - FINS CLOSED 32.14 IN.

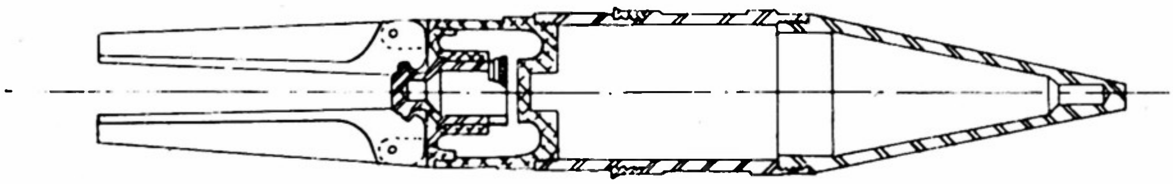
Table VI
T119E4 Modification



Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRB-145	SAE1020	4.00
BODY	DRC-111	24ST4	3.96
HOUSING	DRB-169	24ST4	.98
CHAMBER	DRB-168	24ST4	2.21
PISTON	DRB-55	SAE4140	.51
STOP	DRB-56	SAE4140	.38
FINS	DRB-49	24ST4	.98
PINS	----	STEEL	.08
ASSEMBLY	DRD-103		
INERT LOAD		PLASTER	4.40
PROJECTILE WEIGHT (CALCULATED)			17.5

C. P. .93 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G. 2.32 " " " " " " " "
TOTAL LENGTH - FINS CLOSED 32.14 IN.

Table VII
T119E5 Modification

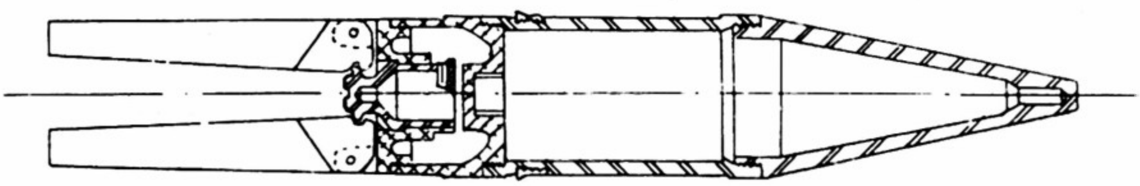


Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRB-145	SAE1020	4.00
BODY	DRC-99	SAE1045	5.68
HOUSING	DRB-197	24ST4	.87
CHAMBER	DRB-199	24ST4	1.51
PISTON	DRB-198	SAE4140	.52
STOP	DRA-173	SAE4140	.08
FINS	MOD. DRB-49	24ST4	.93
PINS	----	STEEL	.08
INERT LOAD		PLASTER	3.83
PROJECTILE WEIGHT (CALCULATED)			17.5

C. P. .67 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G. 1.64 " " " " " " " "

TOTAL LENGTH - FINS CLOSED 28.04 IN.

Table VIII
T119E6 Modification

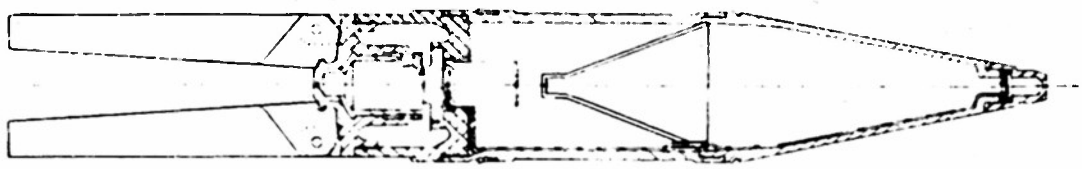


Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRB-145	SAE1020	4.00
BODY	DRC-210	SAE1045	5.21
HOUSING	DRB-197	24ST4	.87
CHAMBER	DRB-199	24ST4	1.51
PISTON	DRB-198	SAE4140	.52
STOP	DRA-173	SAE4140	.80
FINS-CANTED	DRB-285	24ST4	.94
PINS	----	STEEL	.08
INERT LOAD		PLASTER	3.57
PROJECTILE WEIGHT CALCULATED			17.5

C. P. .67 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G. 1.79 " " " " " " " "

TOTAL LENGTH - FINS CLOSED 28.05 IN.

Table IX
T119E7 Modification

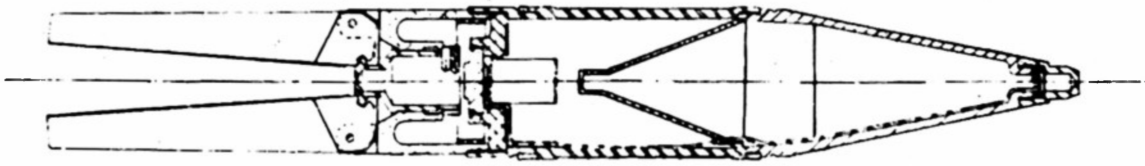


Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRC-342	SAE1020	3.75
BODY	DRC-392	SAE1045	5.47
HOUSING	DRB-197	24ST4	.85
CHAMBER	DRC-393	24ST4	1.60
PISTON	DRB-198	SAE4140	.52
STOP	DRA-173	SAE4140	.09
FINS-CANTED	DRB-285	24ST4	.94
PINS	3/4" LG. X. 2505	SAE1020	.06
NOSE CAP	DRA-699	SAE1030	.20
PLUG	DRA-288	24ST4	.11
OBTURATING BAND	DRB420	COPPER	.20
CONE	DRB398	COPPER	.90
O-RING	Ckcx3-1/8" x 3 7/8"	RUBBER	.01
GAS SEAL	PICATINNY ARSENAL DWG. 75-14-38 PcMKE	COPPER & LEAD	.03
BASE ELEMENT	DRA579	------	.33
WIRE & TAPE	DRA628	NYLON & COPPER	
NOSE ELEMENT	DRA496	BARIUM TITANATE	.02
PIN STRIP	DRA454	BAKELITE	--
GROMMET	DRA492	NYLON	--
SHOCK PAD	DRA493	FELT	--
SHOCK PAD	DRA491	FELT	--
SLEEVE	DRA498	TURBOSIL SILICONE GLASS	--
WASHER			
R. C. ASSY.	DRA598	------	--
INSULATOR	DRA460	FELT	--
ASSEMBLY	DRD332		
COMPOSITION B			2.79
PROJECTILE WEIGHT (CALCULATED)			17.84

C. P. .67 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G. 1.75 " " " " " " " "

TOTAL LENGTH - FINS CLOSED 28.08 IN.

Table X
T119E8 Modification

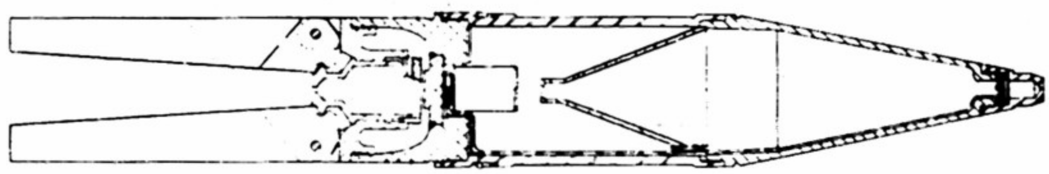


Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRC-342	MALLEABLE IRON	3.49
BODY	DRC-341	SAE1045	5.58
HOUSING	DRC-412	24ST4	1.76
PISTON	DRB-198	SAE4140	.52
STOP	DRA-173	SAE4140	.09
FINS	DRD-334	24ST4 FORGING	1.01
PINS	DRA-730	SAE1020	.06
NOSE CAP	DRA-699	SAE1030	.21
PLUG	DRA-288	24ST4	.11
PLUG	DRB-419	24ST4	.58
OBTURATING BAND	DRB-420	COPPER	.20
CONE	DRB-398	COPPER	.90
O-RING	Ckcx3-1/8" x 3 7/8"	RUBBER	.01
GAS SEAL	PICATINNY ARSENAL DWG. 75-14-38		
	PcMKE	COPPER & LEAD	.03
BASE ELEMENT	DRA-579	------	.33
WIRE & TAPE	DRA-628	NYLON & COPPER	--
NOSE ELEMENT	DRA-496	BARIUM TITANATE	.02
PIN STRIP	DRA-454	BAKELITE	--
GROMMET	DRA-492	NYLON	--
SHOCK PAD	DRA-493	FELT	--
SHOCK PAD	DRA-491	FELT	--
SLEEVE	DRA-498	TURBOSIL SILICONE GLASS	--
WASHER			
R. C. ASSY.	DRA-598	------	--
INSULATOR	DRA-460	FELT	--
ASSEMBLY	DRD-262		
COMPOSITION B			2.79
PROJECTILE WEIGHT (CALCULATED) 17.82 LBS.			

C. P. .68 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. G. 1.73 " " " " " " " "

TOTAL LENGTH- FINS CLOSED 28.21 IN.

Table XI
T119E9 Modification

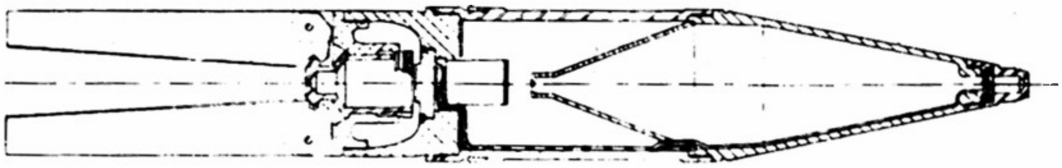


Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRC-342	SAE1020	3.75
BODY	DRC-392	SAE1045	5.47
HOUSING	DRB-552	24ST4	.88
CHAMBER	DRC-442	24ST4	1.83
PISTON	DRB-198	SAE4140	.52
STOP	DRA-173	SAE4140	.09
FINS-CANTED	DRB-285	24ST4	.94
PINS	DRA-730	SAE1020	.06
NOSE CAP	DRA-699	SAE1020	.20
PLUG	DRA-670	24ST4	.11
OBTURATING BAND	DRB-420	COPPER	.20
CONE	DRB-398	COPPER	.90
O-RING	ORD. DWG. Ckcx-3	RUBBER	.01
GAS SEAL	P.A. DWG. NO. 75-14-38 PcMKE	COPPER & LEAD	.03
BASE ELEMENT	DRA-579	------	.33
WIRE & TAPE	DRA-628	NYLON & COPPER	--
NOSE ELEMENT	DRA-496	BARIUM TITANATE	.02
PIN STRIP	DRA-454	BAKELITE	--
GROMMET	DRA-492	NYLON	--
SHOCK PAD	DRA-493	FELT	--
SHOCK PAD	DRA-491	FELT	--
SLEEVE	DRA-498	TURBOSIL SILICONE GLASS	
WASHER			
R. C. ASSY.	DRA-598	------	--
INSULATOR	DRA-460	FELT	--
ASSEMBLY	DRD-346		
COMPOSITION B			2.79
PROJECTILE WEIGHT (CALCULATED)			18.13

C. G. 1.71 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. P. .68 " " " " " " " "

TOTAL LENGTH - FINS CLOSED 28.08 IN.

Table XII
T119E10 Modification



Part	Dwg. No.	Material	Weight (lb.)
NOSE	DRC-342	MALLEABLE IRON	3.49
BODY	DRC-392	SAE1045	5.47
HOUSING	DRB-573	24ST4	.95
CHAMBER	DRC-442	24ST4	1.82
PISTON	DRB-198	SAE4140	.52
STOP	DRA-173	SAE4140	.09
FINS-CANTED	DRD-334	14ST6 FORGING	1.00
PINS	DRA-730	SAE1020	.06
NOSE CAP	DRA-699	SAE1030	.20
PLUG	DRA-670	24ST4	.11
OBTURATING BAND	DRB-420	COPPER	.90
CONE	DRB-398	COPPER	.86
O-RING	DRA-459	RUBBER	--
GAS SEAL	PICATINNY ARSENAL DWG. NO. 75-14-38		
	PcMKE	COPPER & LEAD	.03
BASE ELEMENT	DRA-579	------	.33
WIRE & TAPE	DRA-628	NYLON & COPPER	--
NOSE ELEMENT	DRA-496	BARIUM TITANATE	--
PIN STRIP	DRA-454	BAKELITE	--
GROMMET	DRA-492	NYLON	--
SHOCK PAD	DRA-493	FELT	--
SHOCK PAD	DRA-491	FELT	--
SLEEVE	DRA-498	TURBOSIL SILICONE GLASS	--
WASHER			
R. C. ASSY.	DRA-598	------	--
INSULATOR	DRA-460	FELT	--
ASSEMBLY	DRB-351		
COMPOSITION B			2.79
PROJECTILE WEIGHT (CALCULATED)			18.03

C. G. 1.68 CAL. FROM HINGE PIN CENTER LINE, FINS OPEN
C. P. .68 " " " " " " " "

TOTAL LENGTH - FINS CLOSED 28.08 IN.

Table XIII
T119 Range Data
Charge Development Rounds

PROJECTILE
Model T119
Type E4 & E8 modifications
Weight (Nominal) 17.60 lb
C.G. Location ______
Bourrelet Dia. (Nom.) ______
Special Features Charge Development

TEST GUN
Model T137E1 & T137E2
Type 105 mm Recoilless
Length of Tube 95 in and 105 in
Twist of Rifling Smooth Bore
Sighting Equipment Adapted M17 Elbow Telescope & Elbow Telescope M62E4
Bore Dia. (Lands) 4.134 +.001 in.
Case T63
Primer T81

MISCELLANEOUS DATA
Range 1027 yards
Propellant M10MP Lot PA30239 Lot PA6084
Type ______ web .0335 in Charge Wt. variable
Proof Director E. Huceman
Observers Lucas, Westar, M. Toohig, W. Heevey

Round No.	Projectile No.	Projectile Type[a]	Proj. Weight	Powder Charge (lb oz)	Powder Type	Chamber[d] Pressure (lb/sq in)	Muzzle Velocity Instr.	Muzzle Velocity Actual[b]	Elev. (mils)	Azimuth (mils)	Position of Hit (in) (1027-yd Range) Vert.	Horiz.	Recoil (in. dir)	Wind Vel Dir (mph deg)	Tube Length in	Date Fired	Observations
2638	56	E4	17.49	8-4	PA6084	No Gage	1619	1635	Fired Down Range				14 - R	—	95	8-7-52	1 Yaw Card - Flight Not Observed
2639	X198	E8	17.61	8-5	PA6084	9200 9200	1637	1653	No Target				17 - R	—	95	8-7-52	Forged Fin DRD334-1 - Recovery Box
2640	57	E4	17.51	7-14	PA30239	11200 11200	1716	1732					11½ - R	—	96	8-7-52	1 Yaw Card - Good Flight
2641	X183	E8	17.47	7-12	PA30239	11000 10400	1700	1716	Substitute Fin DRB286				12 - R	—	96	8-7-52	1 Yaw Card - Good Flight
2778	slug		17.30	8-6	PA30239												
2779	X188	E8	17.71	8-6	PA6084	9800 9700	1678	1707	23.5	0	+24.5	+63	—	7-316	105	8-21-52	
2780	X184	E8	17.70	8-5	PA6084	No Gage	1656	1685	23.5	-3	-12	-27	—	9-316	105	8-21-52	

a. All E8 projectiles were received at Erie Ordnance Depot as complete rounds less powder and primer. The cases were cemented to the projectile using Minnesota Mining & Mfg Co. cement EC801, but were not crimped.
b. Retardation Factor = .194 ft/sec/ft. Screen distances: Muzzle to 1st screen 111 ft; 1st to 2nd screen 72.5 ft.
c. All rounds were fired manually
d. M-3 Pressure Gages (cr)

Signed - L. P. Swanbly

CONFIDENTIAL

Table XIV
T119 Range Data
Structural Tests of Components

Date 8-8-56 Program T119 CE

PROJECTILE
Model T119
Type E8 & E9
Weight (Nominal) 1760 & 1780 lb
C.G. Location 7.2 & 6.9 in. from hinge pin ℄
Bourrelet Dia (Nom.) 4.130 $^{-.003}$ in.
Special Features Band 4.164
Blunt Nose

TEST GUN
Model T137E1
Type 105 mm Recoilless
Length of Tube 95 in.
Twist of Rifling Smooth Bore
Sighting Equipment Adapted M17 Elbow Telescope
Bore Dia. (Lands) 4.134 $^{+.001}$ in.

MISCELLANEOUS DATA
Range Pendulum Mount - Recovery Box
Propellant
Type M10 MP web .0336 in Charge Wt. 7lb 14oz
PA 30239
Proof Director F. Lager
Observers Tecnig, Brown, Hervey

Round No.	Projectile No. Type	Proj Weight	Orifice Dia. (in.)	Recoil (in)	Chamber Pressure	Muzzle Velocity Instr	Muzzle Velocity Actual	Elev. (mils)	Azimuth (mils)	Position of Hit Vert.	Position of Hit Horiz.	Corrected Position of Hit - mils Vert.	Corrected Position of Hit - mils Horiz.	Bourrelet Diameter Front	Bourrelet Diameter Rear	Clearance Front	Clearance Rear	Observations
2642	X142 E9	1780	.196	11 1/4 R	11,400 11,200	1685	1716											Fired through 3 yaw cards and into recovery box. Projectile was not recovered but yaw cards indicated satisfactory function and flight. This round was fired to test the functioning of chamber DRC442
2643	X141 E8	1763	.246	10 1/2 R	11,400 11,400	1687	1718											Fired through 3 yaw cards and into recovery box. Projectile was recovered. Yaw cards and recovered projectile indicated satisfactory function and flight. This round was fired to investigate the feasibility of a relaxation of tolerances on the piston and housing cylinder bore. On this piston OD = 1.6840 in., housing clearance = .005 in. Substitute fin DRB285

NOTES:
Retardation factor = .40 ft/sec/ft.
Screen distances: muzzle to 1st screen = 47 ft., 1st to 2nd screen = 62.5 ft.

Signed - L. Swaebly

Table XV
T119 Accuracy Range Data
T119E8 Modification Fired From Smooth Bore Tube

Date Aug 25, 1952 Program T119

PROJECTILE
Model T119
Type E8'
Weight (Nominal) 17.60 lb
C.G. Location 7.2 in. from hinge pin ℄
Bourrelet Dia. (Nom.) 4.130 -.002 in.
Special Features Obturating Band 4.164 in dia.

TEST GUN
Model T137E2
Type 105 mm Recoilless Rifle
Length of Tube 105 in.
Twist of Rifling Smooth Bore
Sighting Equipment M62 F4 Elbow Telescope & Gunners Quadrant
Bore Dia. (Lands) 4.134 +.001 in.
Case T63
Primer T81

MISCELLANEOUS DATA
Range 1029 yds
Propellant
Type P&30259 web .0336 in Charge Wt. 7 lb 12 oz
Proof Director E. Huffman
Observers Dr. V.E. Lucas

Round No.	Proj. Number	Proj. Weight (lb)	Powder Charge (lb oz)	Wind Vel. & Dir. (mph - deg)	Normal Wind Component (mph)	Muzzle Velocity Instr.	Muzzle Velocity Actual[a]	Elev. (mils)	Azimuth (mils)	Position of Hit Vert.	Position of Hit Horiz.	Corrected Position of Hit – mils[b] Vert.	Corrected Position of Hit – mils[b] Horiz.	Observations
2792	slug		7-12											
2793-1	X-185	17.72	7-12			1706	1736	24	-1	-16.5	-49	-1.42	-1.32	Proj. not tipped on nose before loading[c]
2794-2	X-181	17.76	7-12	9-15	2.33	—	—	23	-1	+21.5	-87	+.58	-2.35	Proj hit nos. 2, 3 & 4 Velocity screens
2795-3	X-178	17.57	7-12	9-10	1.56	1717	1746	23	-1	+3	-9.5	+.08	-.26	
2796-4	X-179	17.75	7-12	10-15	2.58	1710	1789	23	-1	-8.5	0	-.23	0	
2797-5	X-197	17.51	7-12	9-15	2.33	1708	1736	23	-1	-45	-39	-1.22	-1.06	
2798-6	X-184	17.70	7-12	9-15	2.33	1704	1782	23	-1	-32.5	-32.5	-.88	-.88	
2799-7	X-192	17.61	7-12	10-15	2.58	1720	1748	23	-1	-40.5	-15	-1.10	-.41	
2800-8	X-191	17.56	7-12	8-15	2.07	1709	1737	23	-1	+3	-20	+.08	-.54	
2801-9	X-199	17.51	7-12	6-30	3.50	1718	1746	23	-1	+3.5	+54.5	+.09	+1.47	Forged Fin DRD 934-1
2802-10	X-180	17.68	7-12	8-15	2.07	1715	1743	23	-1	-31.5	+1.5	-.86	+.04	
2803-11	X-187	17.55	7-12	7-15	1.81	1721	1750	23	-1	-37.5	+39	-1.01	+1.05	
2804-12	X-182	17.64	7-12	7-30	3.50	1705	1733	23	-1	-22	+25	-.59	+.68	

NOTE:
- a Retardation factor = .194 ft/sec/ft
- b Corrected to 23 mils elevation and -1 mil azimuth
- c All rounds except X185 were tipped on nose before loading into the gun
- d All projectiles arrived at E.O.D as complete rounds less powder and primer. The cases were cemented to the projectile with Minnesota Mining & Mfg. Cement EC 801, but were not crimped
- e All rounds were fired manually
- f All projectiles except X199 had a substitute fin DRB 285

Center of Impact V = -.64, H = .11
Probable Error – Vertical .38 mil
Probable Error – Horizontal .59 mil
} 11 Rounds, No. 2 Excluded

Signed - L.P. Swaebly

Optimum Velocity and Bias Angle Needed to Match the Trajectory of the T189 .50 Caliber Spotter-Tracer to that of the T119 105 mm. HEAT Projectile

A velocity and a bias angle have been determined for the T189 spotter-tracer so that its trajectory matches that of the T119 projectile. The following ballistic factors were used in the determination:

T119

Nominal Weight	-	17.70 lbs.
Muzzle Velocity	-	1700 ft/sec.
Form Factor, $i_{2.2}$	-	1.6187
Ballistic Coefficient, $C_{2.2}$	=	0.6398

T189

Ballistic Coefficient

$C_6 = 0.502$

The optimum launching velocity and bias angle for the sub-caliber projectile have been determined by using the theory of least squares. Mismatch (in feet) for several subcaliber launching velocities was determined by Siacci functions and plotted against range from 0 to 1500 yards. Since the trajectories are essentially rigid, the mismatch curve can be rotated about the origin to minimize the mismatch. This angle of rotation is the angle between the tubes, i.e., the angle of bias.

The theory of least squares was used to determine the straight line which would fit the mismatch curve best and at the same time pass through the origin. This is not necessarily the line that gives a minimum for the sum of the squares of the residuals. The best fitting line usually does not pass through the origin. For this application, however, the mismatch line must pass through the origin, since the slope of this line represents the angle through which the trajectory of the minor caliber projectile must be rotated in order to give the best fit to the major caliber trajectory.

This line was obtained in the following manner:

Ordinarily the equation for the least squares line will be of the form:

$$y = a + bx \tag{1}$$

The residuals can be written as

$$r_i = (a+bx_i) - y_i \tag{2}$$

and

$$r_i^2 = a^2 + 2abx_i + b^2 x_i^2 - 2ay_i - 2bx_i y_i + y_i^2 \tag{3}$$

The sum of n residuals will be

$$\Sigma r^2 = na^2 + 2ab\Sigma x + b^2 \Sigma x^2 - 2a\Sigma y - 2b\Sigma xy + \Sigma y^2 \tag{4}$$

When no restrictions are placed upon the possible values of a, the above equation (4) is quadratic in both a and b. By taking the partial derivatives and setting them equal to zero, the usual two normal equations are obtained:

$$\Sigma y = an + b\Sigma x$$
$$\Sigma xy = a\Sigma x + b\Sigma x^2 \tag{5}$$

If, however, we require the line to pass through the origin, then a = o, and equation (4) becomes

$$\Sigma r^2 = b^2 \Sigma x^2 - 2b\Sigma xy + \Sigma y^2 \tag{6}$$

This is quadratic in b so that by taking the partial derivative

$$2b\Sigma x^2 - 2\Sigma xy = 0$$

and $$b = \Sigma xy / \Sigma x^2 \tag{7}$$

With this value for the slope, a line is obtained which will give a minimum sum of the squares of the residuals while subject to the restriction that $\underline{a} = 0$. (see solid straight line in Fig. 3). A line could be found, however, with a $\neq 0$ which would give a lower value for the sum of the squares of the residuals (see broken line in Fig. 3) but such a line would not be suitable in this application.

In this work, the fact that the minor caliber rifle is mounted 0.483 feet above the major caliber gun, is taken into consideration. This initial mismatch is greater than the average mismatch caused by trajectory differences over the entire 1500-yard range. Consequently, it is a factor of great importance.

The sums of the squares of the residuals were computed for each mismatch curve corresponding to a specific launching velocity. The mismatch value at zero range was excluded since it represents the difference in mounting points and consequently cannot be minimized (without making major changes in the mount). A plot of the sums of the squares of the residuals against subcaliber launching velocities gave a parabolic curve. An equation for this curve was derived, from which there was obtained a launching velocity representing a minimum value for the sum of the squares of the residuals. With this optimum launching velocity, values of mismatch were computed which led to a value for the bias angle.

The optimum launching velocity is 1916 ft/sec with an angle of bias of - 2.19 mils. Average mismatch from 100 to 1500 yards is ± 0.382 feet. Maximum mismatch over this range is 0.687 feet (at 1500 yards).

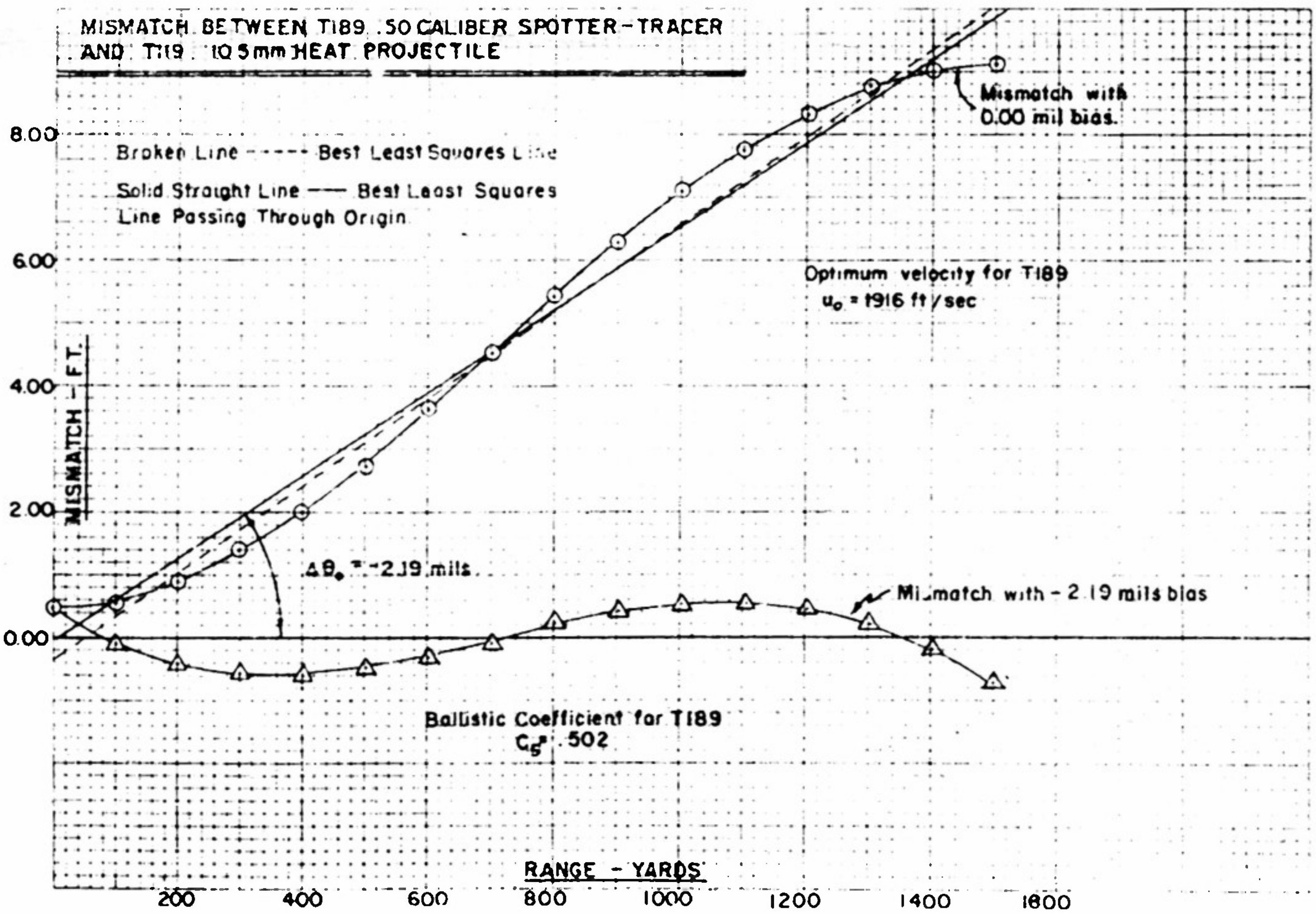


Fig. 3. Mismatch Between T189 .50 Caliber Spotter-Tracer and T119 105 mm. HEAT Projectile.

PENETRATION STUDIES

The penetration studies reported in the Twenty-Third and Twenty-Fourth Progress Reports were concerned with the penetration behavior of DRB 398 cones and of the loss in penetration resulting from the use of the DRC 314 tee in non-rotated shell. These studies have been continued.

Machined Versus Drawn Liners

Nine cones, machined from hard drawn copper bar, and fifteen cones, drawn from copper strip, have been tested for penetration into mild steel target at 0, 25 and 30 rev/sec. The cones were assembled with DRC 376 nose rings, modified DRB 128 bodies and DRB 129 base plugs. The modification to the DRB 128 body consists in machining a register groove in the head end of the body to accomodate the register ring of the DRC 376 body. With this modification the body is substantially the same as the DRC 376 test body. The test assembly is shown in Figure 4. The inspection data for both machined and drawn DRB 398 cones are shown in Table XVI; the penetration data in Table XVII. The booster pellets were assembled in the base plug, e.g. no simulated T208 base elements were used.

The data confirm that both machined or drawn DRB 398 liners (Fig. 11, Twenty-Third Progress Report) will cause equal penetration into mild steel at spin rates of 25 rev/sec and 0 rev/sec. It should be noted that the improvement in penetration at 0 rev/sec, resulting from the more rearward position of the booster (noted in the Twenty-Fourth Progress Report), is also apparent at 25 and 30 rev/sec.

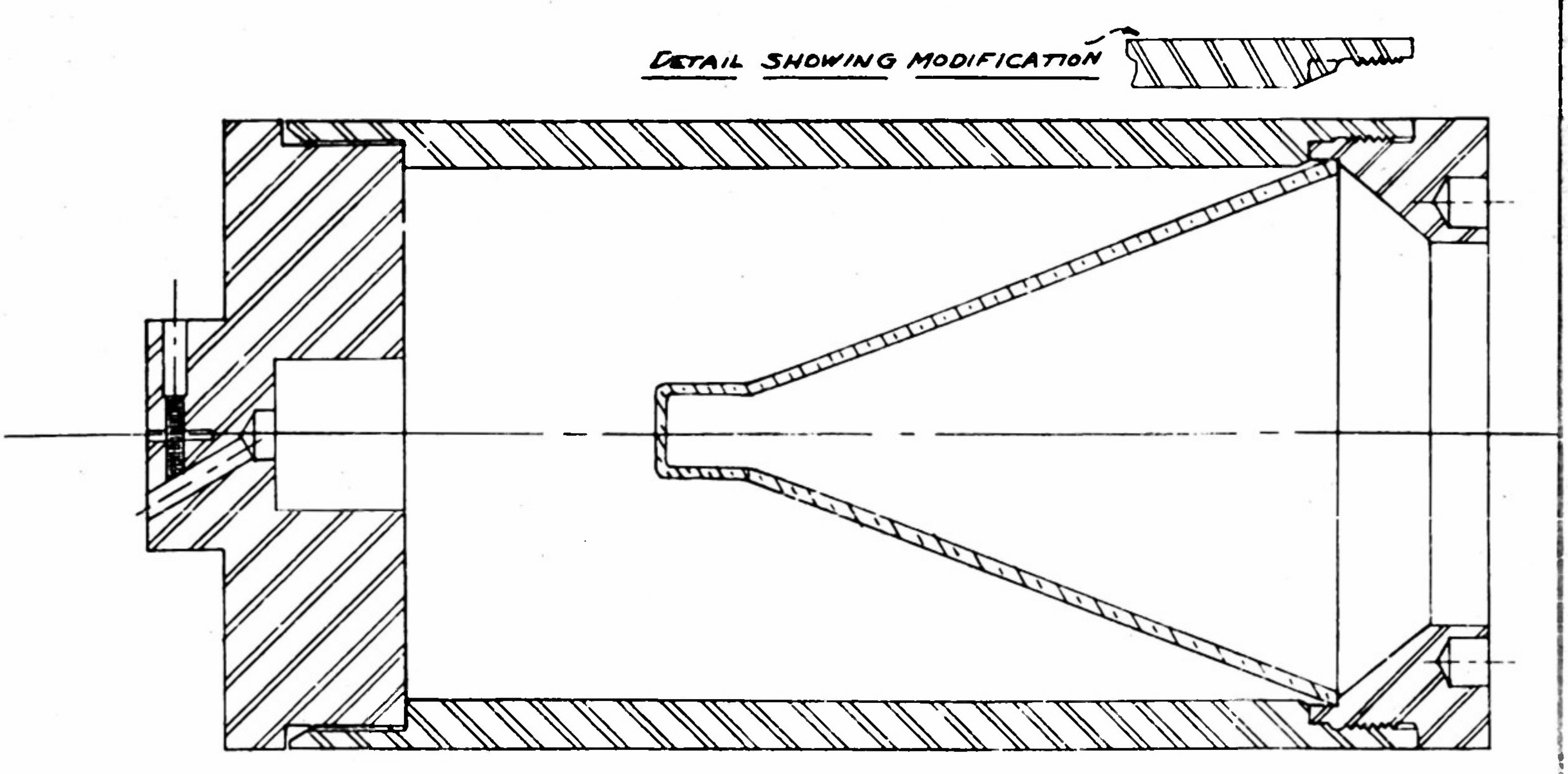


Fig. 4. Test Assembly.
DRC376 Nose Rings, Modified DRB128 Bodies, DRB129 Base Plugs.

Table XVI
Inspection Data
For Machined and Drawn DRB398 Cones

Cone No.	Maximum Variation		Wall Thickness		Concentricity – T.I.R.	
	Transverse	Longitudinal	Maximum	Minimum	Charge To Bourrelet	Cone To Bourrelet
FS517	.002	.002	.103	.101	.002	.001
FS519	.004	.002	.106	.102	.006	.021
FS520	.001	.003	.106	.103	.001	.010
FS522	.001	.002	.106	.104	.004	.007
FS525	.001	.002	.105	.103	.001	.013
FS526	.002	.004	.107	.103	.001	.011
FS527	.001	.005	.106	.101	.001	.046
FS529	.001	.002	.105	.103	.001	.006
FS530	.002	.003	.105	.102	.003	.007
Q685	.003	.002	.104	.101	.002	.019
Q688	.003	.003	.105	.101	.001	.004
Q689	.002	.002	.106	.104	.002	.011
Q690	.002	.003	.104	.100	.002	.007
Q691	.004	.002	.106	.102	.001	.007
Q692	.002	.002	.107	.104	.001	.008
Q693	.003	.003	.104	.101	.002	.013
Q694	.001	.002	.106	.104	.001	.008
Q696	.003	.003	.103	.099	.002	.011
Q697	.004	.003	.105	.100	.002	.007
Q698	.003	.003	.103	.099	.001	.016
Q699	.003	.001	.104	.101	.001	.025
Q700	.001	.001	.103	.102	.001	.012
Q701	.002	.003	.105	.102	.001	.007
Q702	.001	.002	.104	.102	.002	.016

Notes:

1. All measurements are in inches.
2. FS cones were machined from hard drawn copper bar.
   Q cones were drawn from copper strip.

Table XVII
Penetration Data
Machined Versus Drawn Cones

Round No.	lbs. HE	Rev/Sec	Penetration (inches M.S)	Max. Spread (in.)	Std. Dev. (in.)
Machined Cones:					
FS526	2.56	0	20.31		
FS527	2.56	"	21.00		
FS529	2.56	"	20.75		
FS530	2.56	"	21.25		
			Avg. 20.83	.94	±.40
FS517	2.56	+25	15.69		
FS519	2.56	"	16.75		
FS520	2.54	"	15.12		
FS522	2.56	"	16.56		
FS525	2.52	"	15.44		
			Avg. 15.91	1.63	±.71
Drawn Cones:					
Q698*	2.34	0	20.94		
Q699*	2.34	"	20.38		
Q700*	2.34	"	21.25		
Q701*	2.36	"	21.18		
Q702*	2.36	"	20.25		
			Avg. 20.80	1.00	±.48
Q692	2.54	+25	16.12		
Q693	2.58	"	15.88		
Q694	2.58	"	15.94		
Q696	2.58	"	16.56		
Q697*	2.36	"	15.44		
			Avg. 15.79	1.12	±.47
Q685	2.58	+30	13.75		
Q688	2.58	"	14.75		
Q689	2.58	"	13.81		
Q690	2.56	"	13.50		
Q691	2.58	"	13.44		
			Avg. 13.85	1.31	±.54

Notes:
1. DRB398 Machined Liners, DRC376 Rings, DRB128 Bodies (Modified) DRB129 Base Plugs.
2. Loaded at Ravenna Arsenal, Inc. 7-29-52 BAT Lot #14, Comp B Holston Lot 3-126.
3. All rounds tested at a standoff of 7.50 inches.

*4. DRC321 bodies.

Effect of Internal Tee Configuration

It was shown in the Twenty-Fourth Progress Report that the DRC 314 tee reduces the penetration of the DRB 398 cone by approximately four inches at 0 rev/sec and by approximately one inch at 25 rev/sec. The DRC 376 nose ring was used as the control and was considered to have no detrimental effect upon penetration.

DRC 314 tees have been modified and tested to determine whether the interference arises as a result of the 30° taper in the tee cavity, compared to the 51° taper in the nose ring, or whether the interference is in the size of the boom entry hole and boom. Figure 5 shows the modifications tested. The penetration data, summarized in Table XVIII, show that the interference is not primarily a result of the 30° taper. Further tests are planned to separate the effect of the boom entry hole configuration from that of the boom.

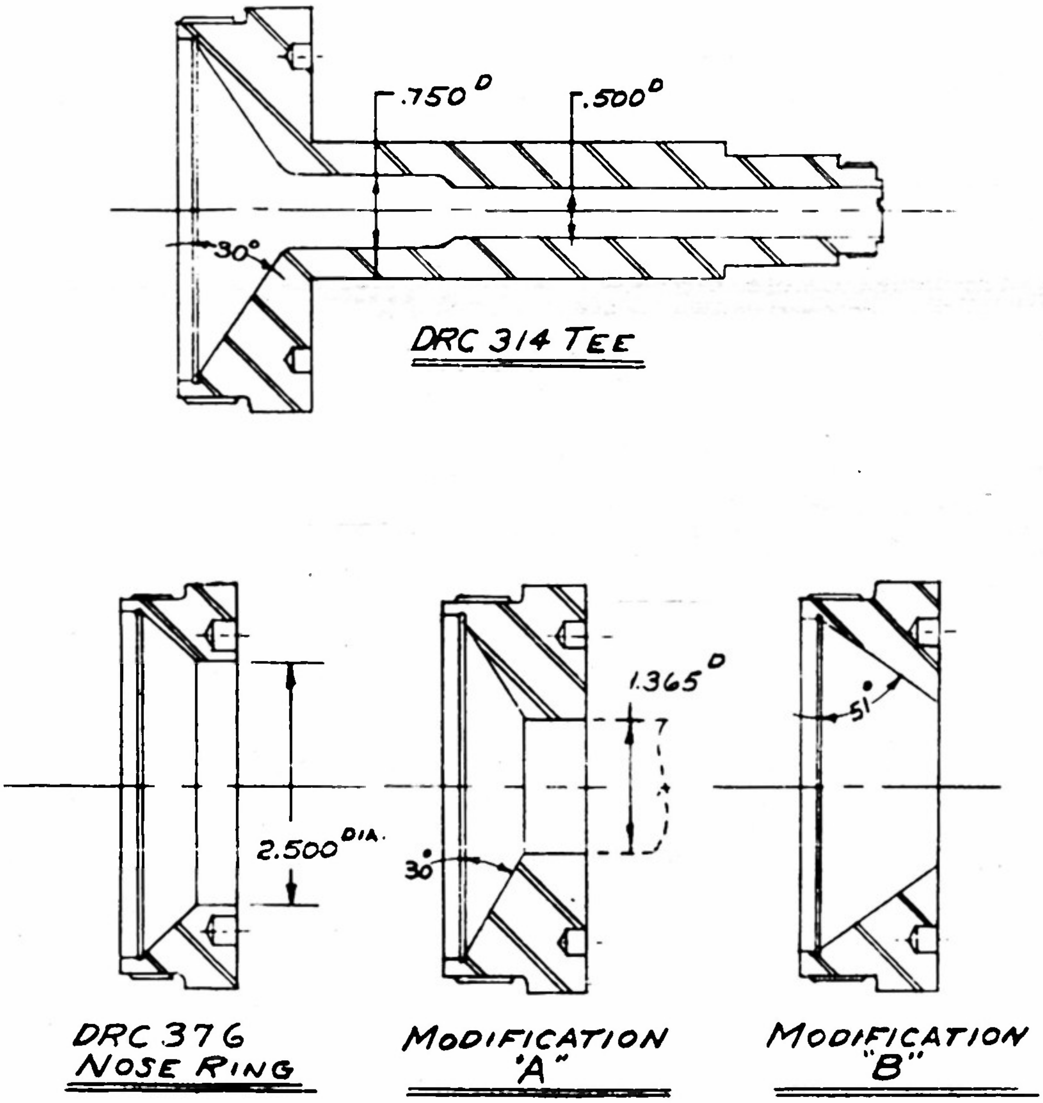


Fig. 5. Tee and Ring Modifications.

Table XVIII
Penetration Data
For Modified DRC314 Tees

Round No.	Nose Ring	lbs. Comp. B	Penetration inches M.S.	Max. Spread (in.)	Std. Dev. (in.)
Q730	DRC314 Tee	2.34	13.00		
Q733	"	2.36	16.06		
Q734	"	2.34	17.50		
			Avg. 15.52	4.50	±2.30
Q698	DRC376 Ring	2.34	20.94		
Q699	"	2.34	20.38		
Q700	"	2.34	21.25		
Q701	"	2.36	21.18		
Q702	"	2.36	20.25		
			Avg. 20.80	1.00	±.48
Q703	Modification A	2.46	21.12		
Q704	"	2.42	19.06		
Q705	"	2.40	18.75		
			Avg. 19.64	2.37	±1.29
Q706	Modification B	2.42	19.88		
Q708	"	2.42	20.00		
Q709	"	2.40	20.38		
			Avg. 20.09	.50	±.25

Notes:
1. DRC321 bodies, DRB129 base plugs, no simulated base element.
2. Loaded at Ravenna Arsenal 7-29 and 8-1, 1952, BAT Load #14, Comp B from Holston 3-126.
3. Standoff is 7.50 inches.

Penetration of DRB 398 Cones Modified To 90 mm. Size

Ten DRB 398 copper cones have been modified to fit into a 90mm size projectile. Figure 6 shows the modified cone. Figure 7 shows the test body used in these penetration tests. The inspection data for the assembled projectiles are shown in Table XIX and the penetration data for three standoff distances in Table XX.

The highest average penetration, 16.40 inches, was observed at a standoff of 6.50 inches. This penetration is lower than that of the unmodified DRB 398 cone by an amount approximately proportional to the reduction in base diameter. Further studies are planned.

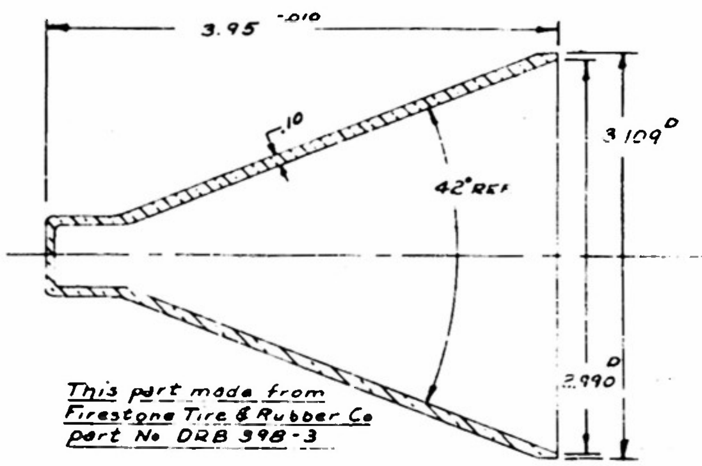
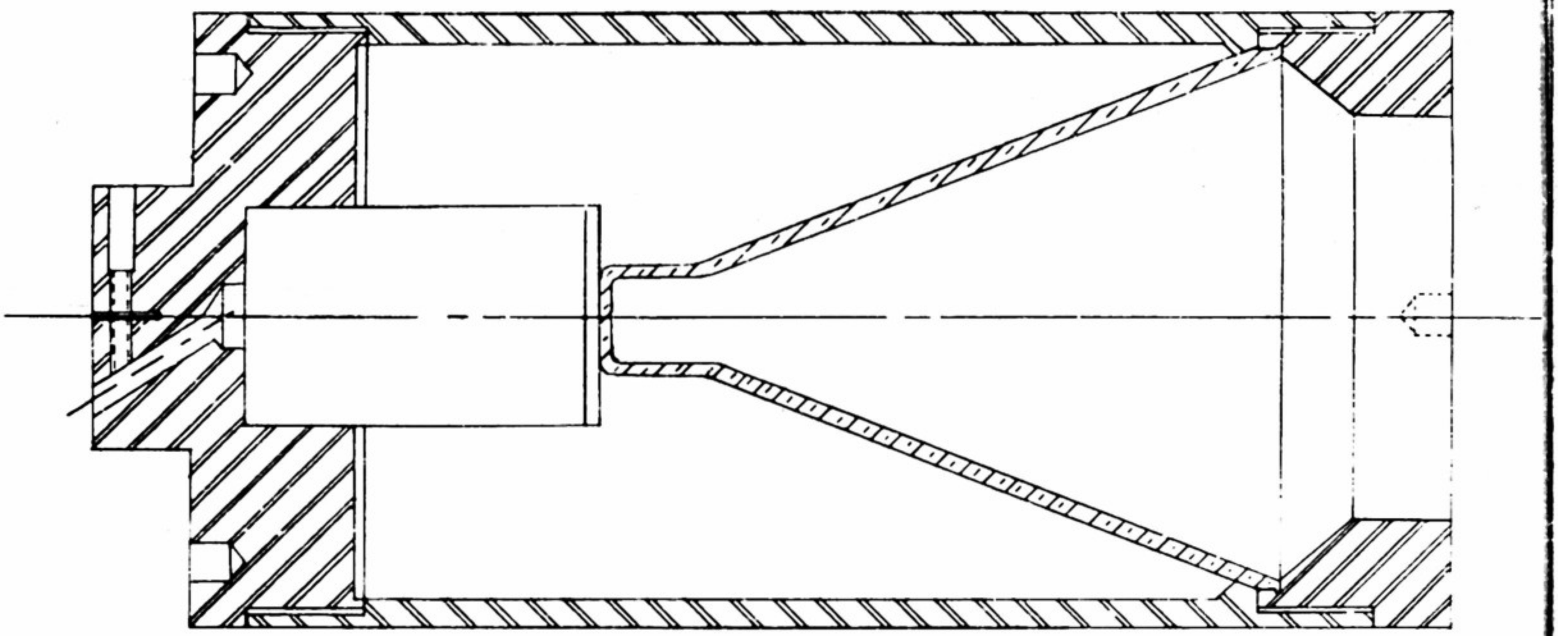


Fig. 6. Modified DRB398 Cone.



FROM MIDWEST RESEARCH INSTITUTE DWG. 687-526

Fig. 7. Test Assembly for 90 mm. Tests.

Table XIX
Inspection Data
For 90 mm. Test Projectiles

Rd. No.	Total Ind. Runout — inches				Projectile Weight - lbs		
	Cone Tip	Cone Base	Body I.D.	Body O.D.	Loaded	Empty	Comp.B.
1	.042	.016	.007	.002	6.80	4.98	1.82
2	.065	.014	.016	.002	6.80	4.98	1.82
3	.030	.005	.006	.001	6.80	4.96	1.84
4	.061	.007	.010	.002	6.82	5.02	1.80
6	.017	.010	.007	.002	6.84	4.98	1.86
7	.060	.011	.010	.002	6.82	5.00	1.82
8	.011	.002	.005	.001	6.76	4.90	1.86
9	.023	.007	.005	.001	6.80	5.00	1.80
10	.053	.015	.008	.002	6.78	4.98	1.80
11	.020	.005	.003	.002	6.78	4.96	1.82

Notes:
1. Cone tip runout measurements taken on outside cone surface, cone mounted in nose ring and assembled to body.
2. Cone base runout measurements made on inside cone surface, 1 inch above the base, cone assembled in ring and body.
3. Projectile weights as recorded do not include weight of the base plug.

Table XX
Penetration Data
For 90 mm. Test Projectiles

Round No.	Standoff(in.)	Penetration inches M.S.	Maximum Spread (in.)	Std. Deviation (in.)
1	4.0	15.44		
2	4.0	14.38		
3	4.0	15.25		
		Avg. 15.02	1.06	±.57
4	6.5	16.50		
6	6.5	16.25		
7	6.5	16.44		
		Avg. 16.40	0.25	±.13
8	9.5	14.00		
9	9.5	15.56		
10	9.5	17.38		
11	9.5	18.62		
		Avg. 16.39	4.62	±2.04

Notes:
1. DRB398 copper cones modified to 3.109 base diameter.
2. Penetration Test base elements as shown in Fig. 12 of the Twenty-third Progress Report, Firestone Tire and Rubber Company.
3. Loaded at Ravenna Arsenal 7-10-52 to 7-29-52, BAT Lot #14, Holston Lot 3-126.
4. Tested at Erie Ordnance Depot 8-18-52 to 8-19-52.
5. All rounds tested at 0 rps.

Future Program

1. Conduct penetration versus standoff tests for 45° and 20° copper cones (100-inch wall) with head of H.E. held constant at 3.63 in.

2. Evaluate the influence of DRC 314 tees made of (a) mild steel (b) high ductility malleable iron, and (c) low ductility malleable iron.

3. Continue tests to determine the effect of interior tee configuration upon penetration.

4. Continue scaling studies with smaller liners.

Nose Element Studies

In further consideration of the functioning properties of barium titanate crystals, two series of tests were conducted, (1) a series of rounds, involving regular T138 type tee and nose element assemblies, were fired for recovery to determine the effect of the setback forces on the crystals and (2) a series of crystal assemblies were tested in a drop tester to determine if the crystal from a T138 assembly could break without functioning a BS28 indicator.

Effect of Setback on T222 Crystal Assembly

Twelve tee sections embodying different crystal arrangements were prepared. Three such assemblies were mounted in T138E57, inert projectiles, as shown in Fig. 8. With this arrangement damage to the nose element assemblies is the result of setback forces either during acceleration on firing or during deceleration in the recovery box. Care was taken that the sawed-off tees were aligned with the axis of the projectile and the sections were in firm contact with the base of the projectile.

The crystals were mounted in a variety of ways (1) in four cases the crystal was glued to the tee (2) in six cases rubber spacers were placed between the tee cap and the crystal to produce a slight compressive force in the crystal (3) in four cases heat squibs were connected across the crystals to determine if the forces on the crystal during firing or deceleration would generate sufficient energy to function a detonator.

The four rounds, with twelve test assemblies, were fired into a recovery box from a T137 recoilless rifle. The crystals were subjected to the usual setback forces during firing and during deceleration in the recovery box, but were not subjected to the impact damage the tee normally experiences in the recovery box. Table XXI presents the conditions and results of these firings.

The data are not conclusive. In general it appears that the crystals under compression suffered the least damage. None

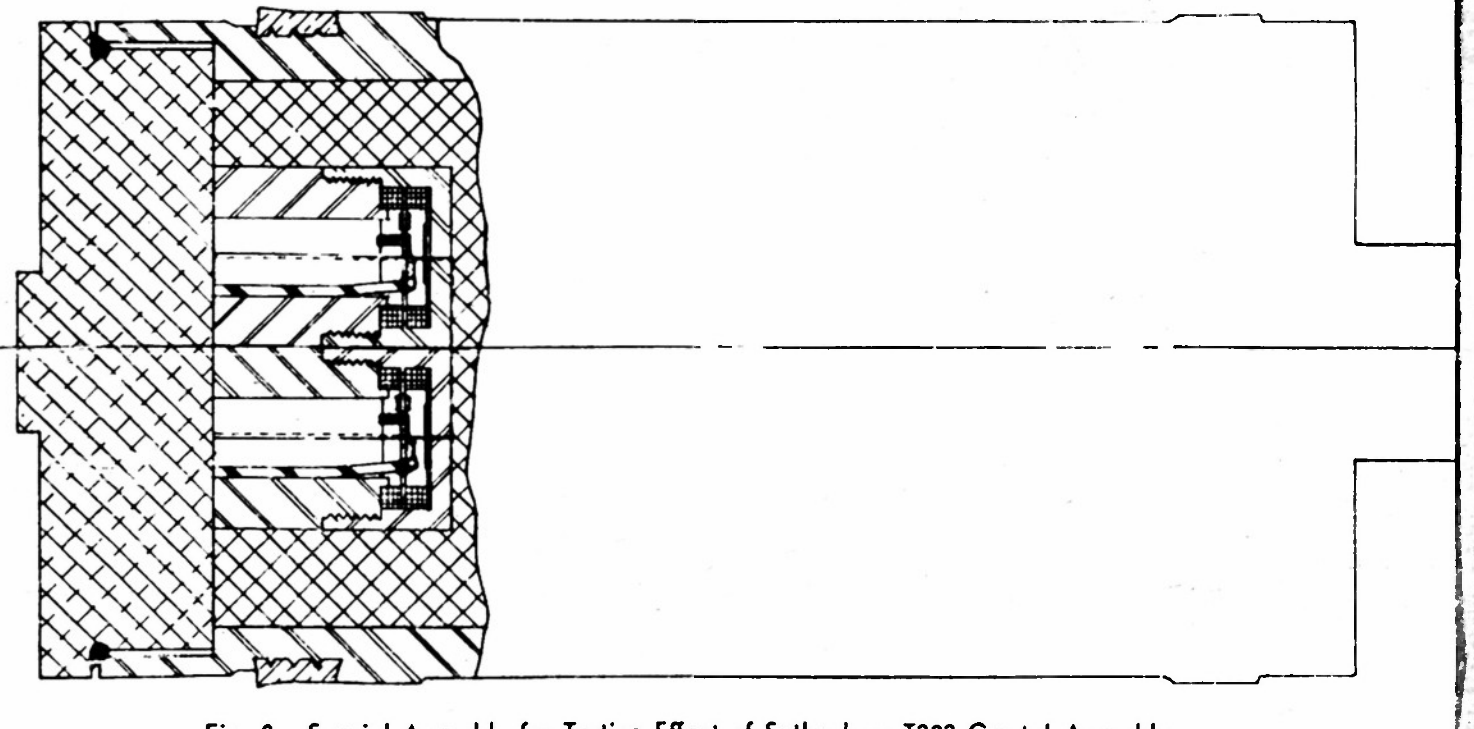


Fig. 8. Special Assembly for Testing Effect of Setback on T222 Crystal Assembly.

Table XXI
Test Data
Effect of Setback on T222 Crystal Assembly

Crystal No.	Crystal Glued	Rubber Spacer	Heat Squib	Condition of Crystal	Condition of Squib
1		x	x	Broken	Didn't Function
2		x		Broken	
3	x	x		Not Broken	
4		x	x	Broken	Didn't Function
5		x		Slightly Chipped	
6	x	x		Not Broken	
7			x	Badly Broken	Didn't Function
8				Badly Broken	
9	x			Broken	
10			x	Badly Broken	Didn't Function
11				Broken	
12	x			Broken	

of the heat squibs functioned and thus it appears that the crystal can be subjected to forces sufficient to cause it to shatter without functioning the detonator. From the appearance of the assemblies after recovery it is not evident whether the breaking of the crystals occurs during setback or during the deceleration cycle.

Drop Tests With Crystal Assemblies

A series of tests using the drop tester (Fig. 49 of the Third Progress Report) were conducted in further attempts to determine whether the crystal in a T138 fuze assembly can break without functioning BS28 indicators. Special tee caps were mounted on standard tee-crystal assemblies as shown in Fig. 9. The caps had an outside diameter of 2 inches, a clearance between cap and crystal of .100 in. and shouldered on the second offset of the T138 tee. This oversize tee was used in an effort to minimize

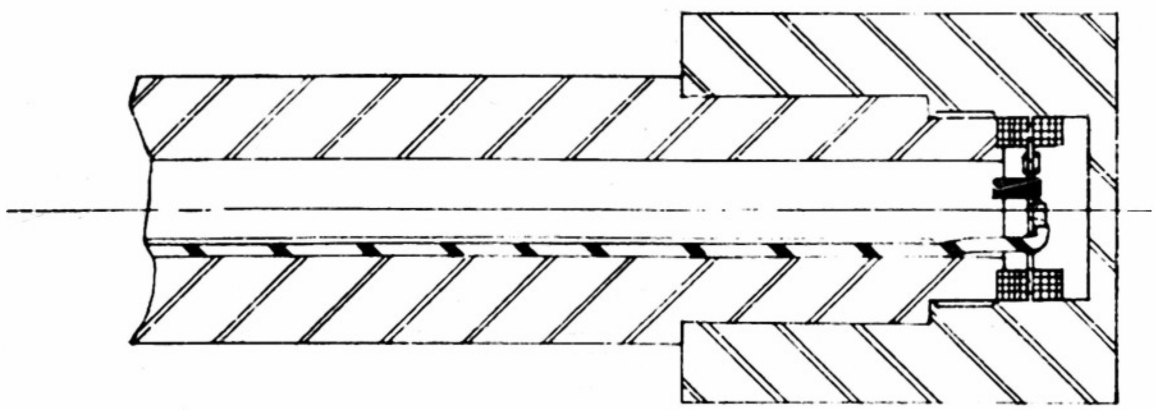


Fig. 9. Special Tee Cap for Drop Tests.

tee distortion upon striking. The drops were approximately 32 feet.

Test 1

Four drops were made with the crystal glued in place. Only one BS28 indicator functioned although all crystals were broken.

Test 2

Three tests were conducted with a compressed sponge rubber pad in front of the crystal. All three drops functioned BS28 indicators and all crystals were broken.

Test 3

Two tests were made in which the sponge rubber was placed behind the crystal in such a way as to hold it against the back surface of the tee cap. Both drops functioned the BS28 indicator and the crystals were broken.

Test 4

Three drops were made in which it was intended that felt padding should be placed on the upper surface of the contact plate, but not between the crystal material and the tee cap. One BS28 indicator functioned but subsequent examination of this assembly indicated that the felt had been misplaced slightly so that there was a partial compression of the crystal material.

The above tests indicate that the certainty of functioning is enhanced by the use of the foam rubber pad between the tee cap and the crystal. Four additional drops were made to confirm this observation but in this series the first and fourth drops failed to function the BS28 indicators. Additional tests are planned.

Test Firing of T222E5 Fuze Element (DRD 328 Base Element)

Twenty base elements (see Fig. 10) for the T222E5 fuzes were assembled and tested in the centrifuge and found to function satisfactorily. These base elements were then fired in projectiles at the Erie Ordnance Depot and recovered. Sixteen of the twenty base elements functioned normally. The remaining four base elements were found to be corroded badly, presumably by moisture from the plaster cast. When this corrosion was removed the base elements functioned normally in the centrifuge. The rusting and corrosion of metal parts emphasizes the need for surface treatment of all metal parts.

Jolt and Jumble Test on PD T223E2 Fuze

Three PD T223E2 fuzes (see Fig. 11) were given the standard military Jolt and Jumble tests at Picatinny Arsenal. Examination of the fuzes, after being subjected to the tests, showed that all were safe to handle. In one case the number three setback pin was sheared which unlocked the rotor. However, the delay element M2 was still locked in the safe position. On the basis of these tests the PD T223E2 fuze is probably safe for normal shipment procedures.

Firing of PD T223E2 Fuzes

Six PD T223E2 fuzes were fired for recovery at Erie Ordnance Depot. Four fuzes functioned completely. One failed to arm because of some failure of the setback mechanism. The rotor of the sixth fuze had been within five degrees of being fully armed when it struck the recovery box. This was indicated by the point of impact of the detonator retaining screw which is driven back by the flash from the M18 detonator. The recovery box was 134 feet from the gun and since the design arming range is between 100 and 200 feet it is possible that the fuze would have armed completely in 200 feet.

Finish of Fuze Parts

After consultation with the personnel of the fuze section at Picatinny Arsenal it has been decided to test the use of .0002-inch zinc plating with a supplemental chromate dip (Spec. QQ2325 Type II Class 3) on all metal fuze parts except springs. Springs will be given a cadmium plate and chromate dip. (Spec. QQP416 Type II Class C).

Future Program

1. Conduct Jolt and Jumble Tests on T222E5 base elements.

2. Test fire T222E5 base elements assembled in T222 fuze assemblies for actual functioning, first in inert rounds and then in HEAT rounds.

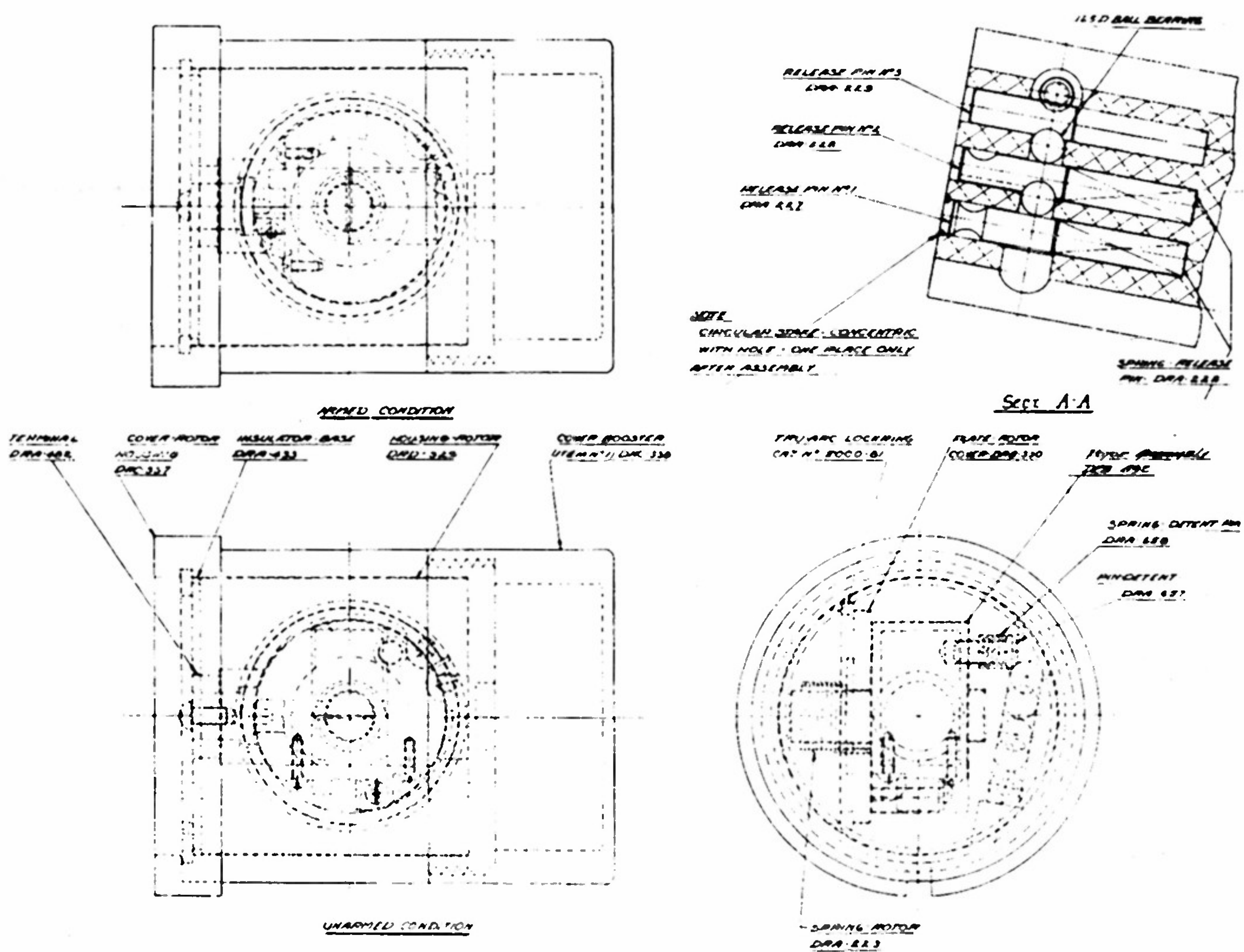


Fig. 10. DRD 328 Base Element.

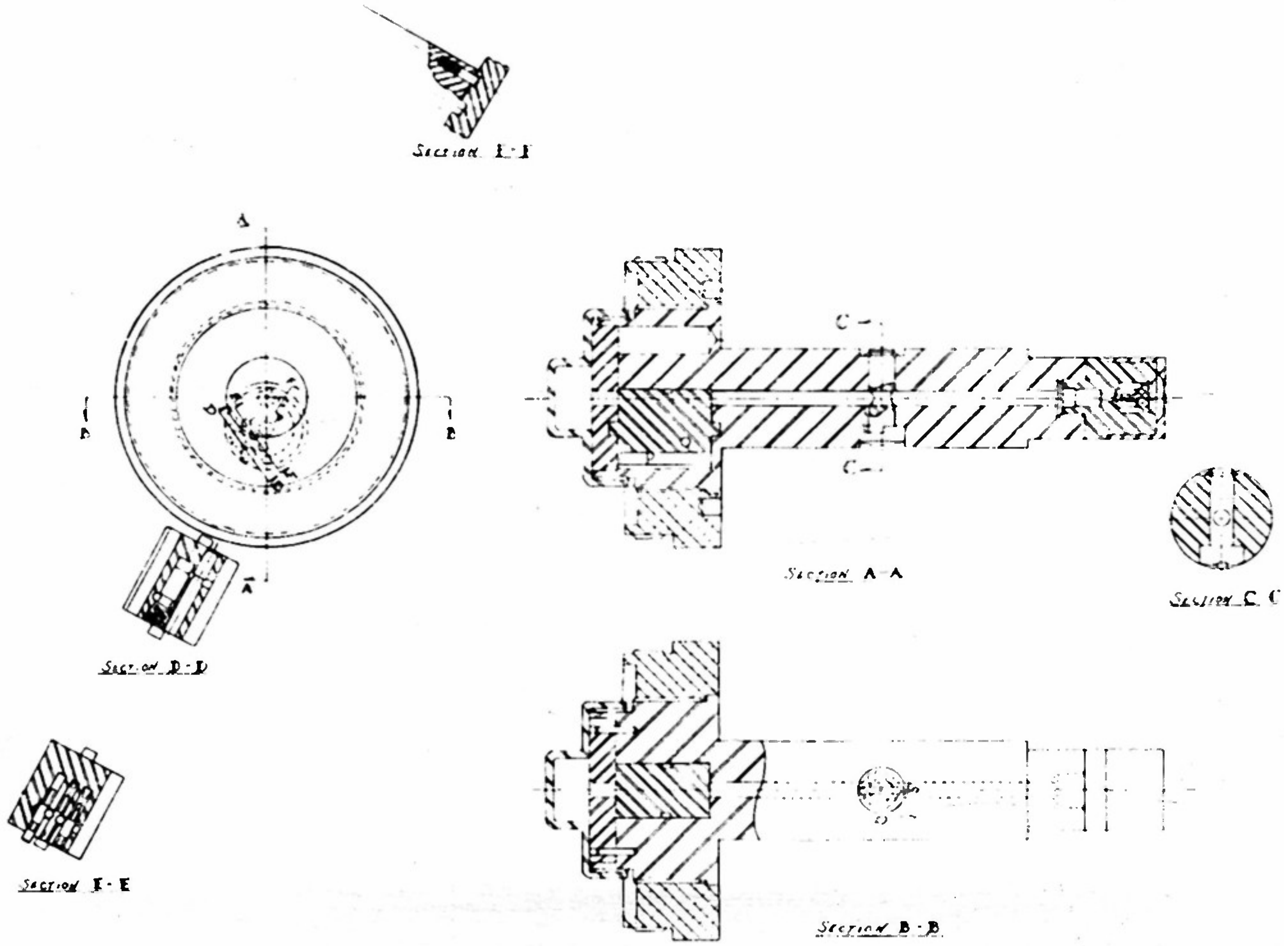


Fig. 11. PD T223E2 Fuze.